Available online at www.sciencedirect.com
ScienceDirect
Drug and Alcohol Dependence 99 (2009) 1–10
DRUG and ALCOHOL DEPENDENCE
www.elsevier.com/locate/drugalcdep

Review

Caffeinated energy drinks—A growing problem

Chad J. Reissig [a], Eric C. Strain [a], Roland R. Griffiths [a,b,*]

[a] *Department of Psychiatry and Behavioral Sciences, The Johns Hopkins University School of Medicine, 5510 Nathan Shock Drive, Baltimore, MD 21224, USA*
[b] *Department of Neuroscience, The Johns Hopkins University School of Medicine, 5510 Nathan Shock Drive, Baltimore, MD 21224, USA*

Received 11 March 2008; received in revised form 4 August 2008; accepted 4 August 2008
Available online 21 September 2008

Abstract

Since the introduction of Red Bull in Austria in 1987 and in the United States in 1997, the energy drink market has grown exponentially. Hundreds of different brands are now marketed, with caffeine content ranging from a modest 50 mg to an alarming 505 mg per can or bottle. Regulation of energy drinks, including content labeling and health warnings differs across countries, with some of the most lax regulatory requirements in the U.S. The absence of regulatory oversight has resulted in aggressive marketing of energy drinks, targeted primarily toward young males, for psychoactive, performance-enhancing and stimulant drug effects. There are increasing reports of caffeine intoxication from energy drinks, and it seems likely that problems with caffeine dependence and withdrawal will also increase. In children and adolescents who are not habitual caffeine users, vulnerability to caffeine intoxication may be markedly increased due to an absence of pharmacological tolerance. Genetic factors may also contribute to an individual's vulnerability to caffeine-related disorders including caffeine intoxication, dependence, and withdrawal. The combined use of caffeine and alcohol is increasing sharply, and studies suggest that such combined use may increase the rate of alcohol-related injury. Several studies suggest that energy drinks may serve as a gateway to other forms of drug dependence. Regulatory implications concerning labeling and advertising, and the clinical implications for children and adolescents are discussed.

Keywords: Caffeine; Energy drink; Adolescents; Overdose; Withdrawal; Dependence; Alcohol; Gateway drug

Contents

* Corresponding author at: Department of Psychiatry and Behavioral Sciences, The Johns Hopkins University School of Medicine, 5510 Nathan Shock Drive, Baltimore, MD 21224, USA. Tel.: +1 410 550 0034; fax: +1 410 550 0030.
E-mail address: rgriff@jhmi.edu (R.R. Griffiths).

0376-8716/$ – see front matter © 2008 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.drugalcdep.2008.08.001

1. Introduction

In 2006, annual worldwide energy drink consumption increased 17% from the previous year to 906 million gallons, with Thailand leading the world in energy drink consumption per person, but the U.S. leading the world in total volume sales (Zenith International, 2007). Although "energy drinks" first appeared in Europe and Asia in the 1960s, the introduction of "Red Bull" in Austria in 1987 and in the U.S. in 1997 sparked the more recent trend toward aggressive marketing of high caffeine content "energy drinks". Since its inception, the energy drink market has grown exponentially, with nearly 500 new brands launched worldwide in 2006 (Johnson, 2006), and 200 new brands launched in the U.S. in the 12-month period ending July 2007 (Packaged Facts, 2007). From 2002 to 2006, the average annual growth rate in energy drink sales was 55% (Packaged Facts, 2007) (Fig. 1). The total U.S. retail market value for energy drinks (from all sources) was estimated to be $5.4 billion in 2006 and has shown a similar annual growth rate over this same period (47%) (Packaged Facts, 2007). These drinks vary widely in both caffeine content (ranging from 50 to 505 mg per can or bottle) and caffeine concentration (ranging from 2.5 to 171 mg per fluid ounce) (Table 1). For comparison, the caffeine content of a 6 oz cup of brewed coffee varies from 77 to 150 mg (Griffiths et al., 2003). The main active ingredient in energy drinks is caffeine, although other substances such as taurine, riboflavin, pyridoxine, nicotinamide, other B vitamins, and various herbal derivatives are also present (Aranda and Morlock, 2006). The acute and long-term effects resulting from excessive and chronic consumption of these additives alone and in combination with caffeine are not fully known. Although the full impact of the rise in popularity of energy drinks has yet to be realized, the potential for adverse health consequences should be considered and may be cause for preemptive regulatory action.

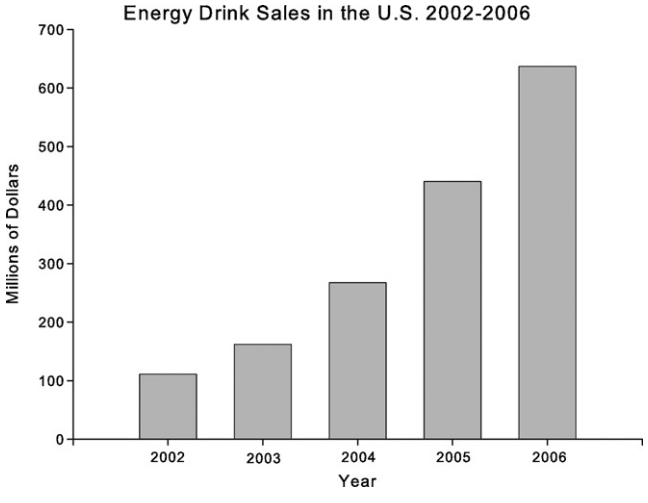

Fig. 1. Energy drink sales in millions of dollars in the United States from 2002 to 2006. Data are based on scanner data from over 32,000 stores such as supermarkets, drug stores, and discount merchandisers other than Wal-Mart. Data are from retailers with $2 million or more in annual sales but exclude: clubstores/warehouse clubs, convenience stores, dollar/variety stores, foodservice, vending, concession sales and specialty channels/retailers of all types (e.g., gourmet/specialty food stores, hardware/home improvements stores, military exchanges) (Packaged Facts, 2007 used with permission).

2. Regulatory aspects

The regulation of beverages to which caffeine is added has been challenging, partly because of the widespread and long-term use of beverages such as coffee and tea in which caffeine is a natural constituent. Nonetheless, several countries have enacted measures to regulate the labeling, distribution, and sale of energy drinks that contain significant quantities of caffeine. The European Union requires that energy drinks have a "high caffeine content" label (European Union, 2007) and Canada requires labels indicating that Red Bull should not be mixed with alcohol and that maximum daily consumption not exceed two 8.3 oz cans (Health Canada, 2005). Norway restricts the sale of Red Bull to pharmacies, while France (until recently) and Denmark have prohibited the sale of Red Bull altogether (Ari Kapner, 2004).

The history of the regulation of caffeine containing beverages in the U.S. serves as an illustrative example of the complexity of the regulatory issues involved in their sale, use, and promotion. Historically, the U.S. Food and Drug Administration (FDA) has regulated caffeine-containing soft drinks as foods. In 1980, citing health concerns about caffeine, the FDA proposed to eliminate caffeine from soft drinks (Food and Drug Administration, 1980). In response, soft drink manufacturers justified adding caffeine to soft drinks on the basis that caffeine was a flavor enhancer (PepsiCo Inc., 1981), although the scientific basis for that claim has since been challenged (Griffiths and Vernotica, 2000; Keast and Riddell, 2007). If caffeine had not been accepted as a flavor enhancer, but had been regarded as a psychoactive ingredient, soft drinks might have been regulated by the FDA as drugs. However, the FDA approved caffeine and limited the maximum caffeine content of cola-type soft drinks to 0.02% caffeine, or 71 mg/12 fluid oz (Food and Drug Administration, 2003).

Although drink manufacturers initially complied with the FDA caffeine limits, the marketplace has changed dramatically since the introduction of energy drinks. At least 130 energy drinks now exceed 0.02% caffeine (Energyfiend website, 2008), including one that contains 505 mg in a 24 oz can (the equivalent of 14 cans of a typical cola or several cups of coffee) (Table 1). Many manufacturers are not subject to the prior caffeine limits by claiming that their new products fall under the 1994 Dietary Supplement Health and Education Act, which classifies products deriving from herbs and natural sources as dietary supplements rather than drugs (Ari Kapner, 2004). Other manufacturers appear to be ignoring the FDA caffeine limits and FDA has not enforced the limits. The FDA has been lax in regulating the caffeine content of energy drinks and does not require warning labels advising proper use or the amount of caffeine in the product, as it does for over-the-counter (OTC) caffeine-containing stimulants. According to the FDA (Food and Drug Administration, 2007a), over-the-counter stimulant drug prod-